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PLANNING + DESIGN

Technical Memorandum

To: **Andrew Meeker, City of Greenville**

From: John Cock and Tony Salomone, *Alta Planning + Design*

Date: January 12, 2011

Re: Greenville Bicycle Master Plan – Cycle Zones Analysis

This report summarizes technical information related to the Cycle Zone Analysis (CZA) used to evaluate existing bikeway conditions for the Greenville Bicycle Master Plan. This analysis aids the planning effort by:

- Highlighting factors that affect cycling conditions in different areas of the city
- Identifying zones with the highest potential for good cycling conditions to maximize the efficacy of investments
- Guiding the development of new bikeway design tools that enhance user experience and maximize cycling potential

The city was divided into 14 zones of roughly similar cycling characteristics with boundaries determined by combining census tracts and streets with high average daily traffic volumes. Such factors have a tendency to create their own bikability boundaries.

The goal of the CZA is to evaluate the bicycling experience throughout the city. This analysis projects which areas have the greatest potential for cycling through an evaluation of connectivity, trip attractors, and trip barriers. Each metric incorporated the following data:

- Density - roadway network density, bicycle network density
- Connectivity – roadway network connectivity, bicycle network connectivity
- Attractors – public facilities, commercial land use designations
- Barriers – highways, railroads, roadway slopes over five percent

The Bicycle Master Plan will use this information to target investment recommendations to locations that are likely to result in the highest increase in cycling.

Data Gathering and Synthesis

The analysis was based on existing data from the City of Greenville.

The reasoning for each measure's inclusion in the CZA is discussed in more detail below. In many cases, the selected measures were translated into density units – square acre or linear feet - to account for size variations between zones.

Each of the factors was multiplied by a weight and then normalized on a scale of 1 – 3. The resulting normalized scores were summed to create a composite score of overall bikability per zone. This methodology can easily be modified by the City in future to include additional factors and calibrated and weighted based on the purpose of that specific model run.

The following section discusses each of these factors, outlining the rationale for their inclusion in the model and a basic methodology for how they were calculated.

Roadway and Bikeway Density

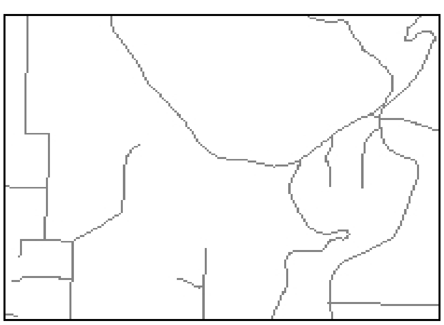
Table 1. Roadway and Bikeway Density Cycle Zone Factors

Cycle Zone	Area (Acres)	Roadway Length	Roadway Density	Bikeway Length	Bikeway Density
1	1,136	194,707	171	34,532	0.18
2	1,804	271,634	151	29,195	0.11
3	515	100,552	195	4,250	0.04
4	798	136,163	171	5,972	0.04
5	1,738	257,413	148	0	0
6	1,275	168,978	133	8,633	0.05
7	970	90,638	93	2,923	0.03
8	1,968	145,355	74	0	0
9	1,962	95,255	49	4,228	0.04
10	965	39,868	41	16,427	0.41
11	1,582	58,835	37	0	0.00
12	2,108	233,281	111	0	0.00
13	1,067	113,729	107	2,413	0.02
14	1,302	174,044	134	0	0

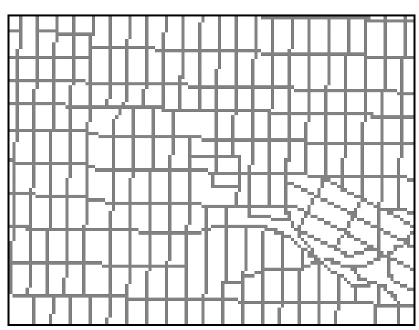
Total Roadway Network Density:

Definition: The density in linear feet per square acre of all roads in the cycling zone. This includes roads of all types except for interstate highways, where bikes are not allowed.

Example:



Sparse network limits rider choice

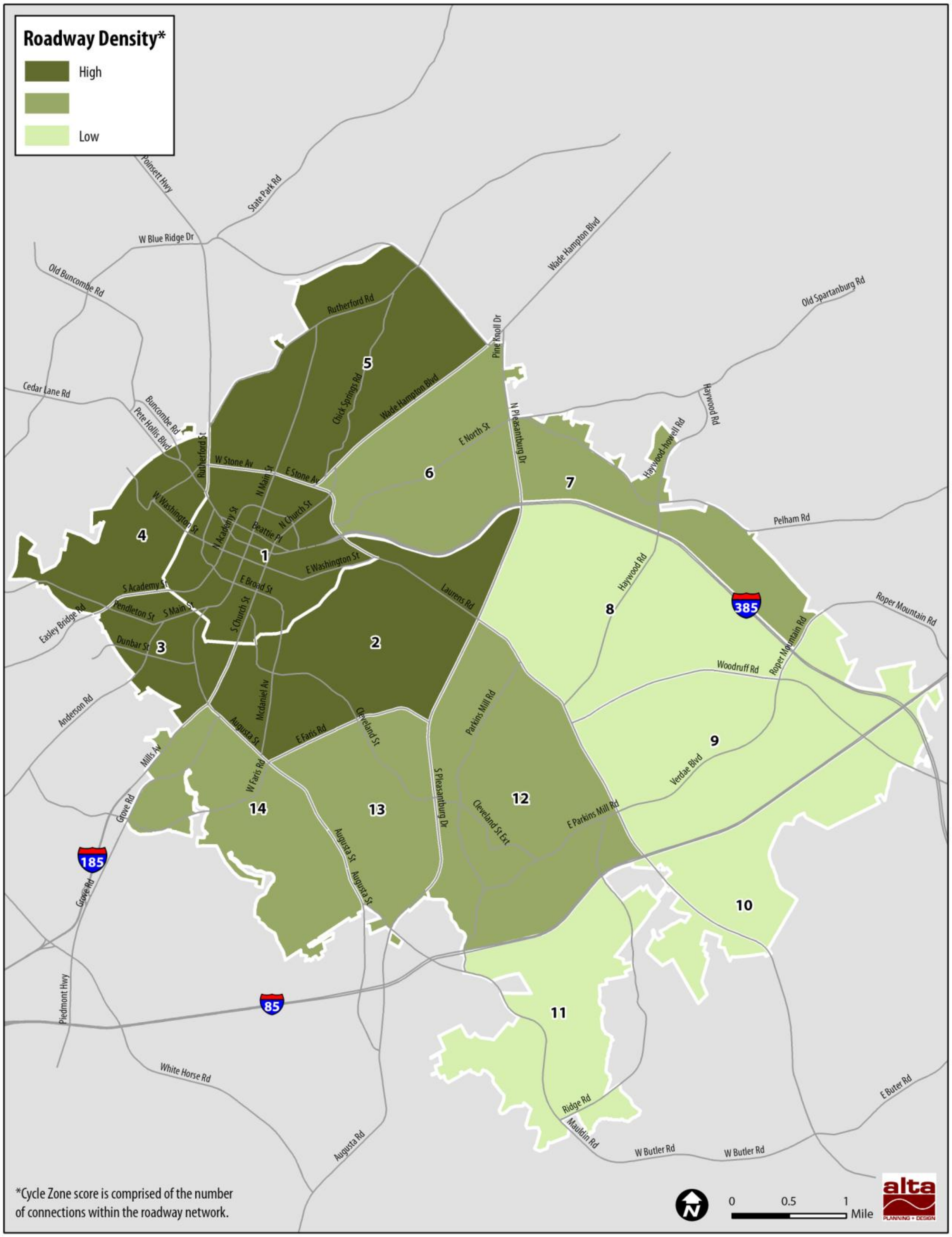


Dense network facilitates rider choice

Reasoning: A zone with a greater density of roads will facilitate a better cycling experience. Riders will be able to go more places and have greater route choice.

Basic Methodology: GIS tools were used to determine the overall length of roads falling within each cycle zone. This was divided by the zone's acreage to obtain an average road network density.

Figure 1. Roadway Density CZA Scores



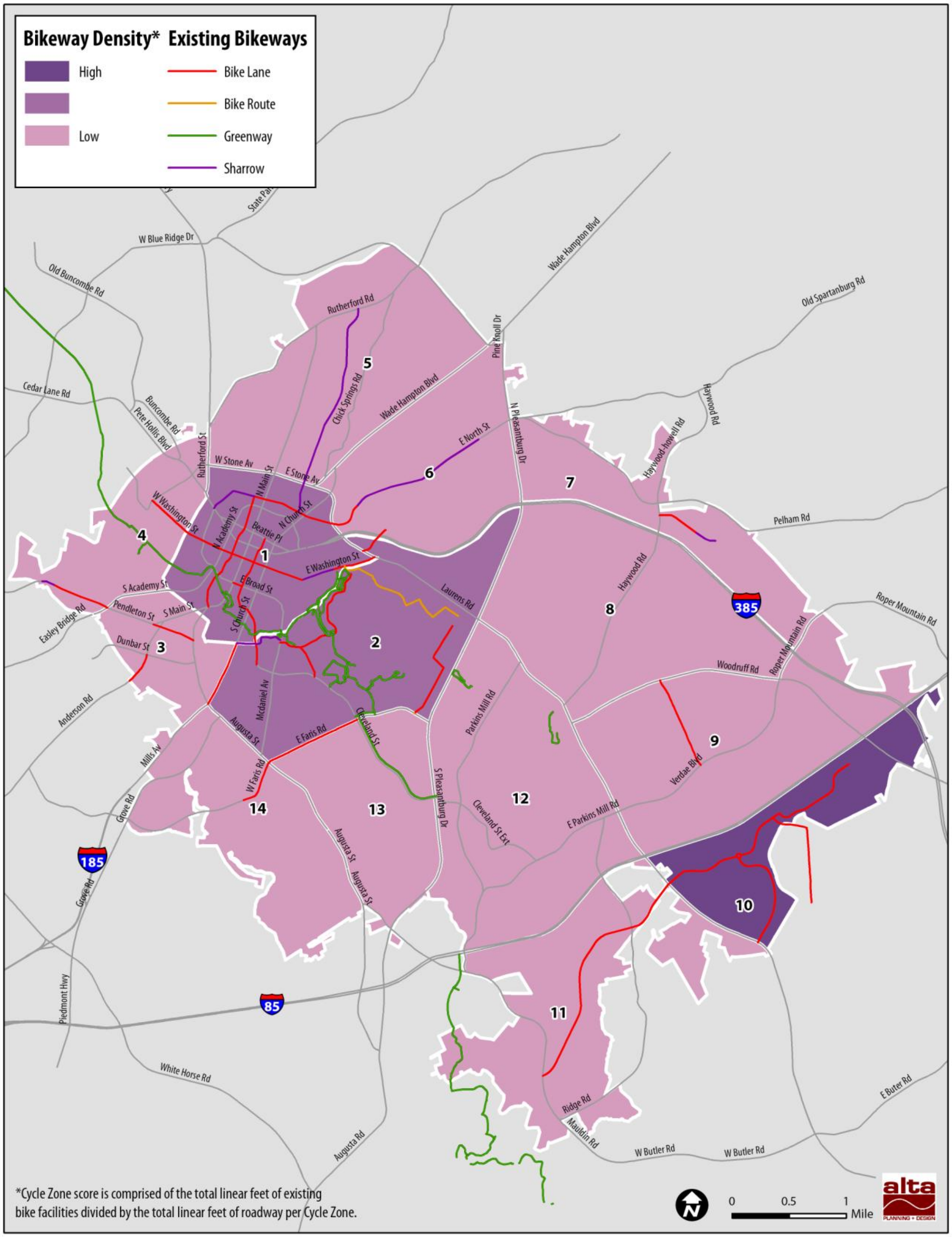
Bike Network Density:

Definition: The proportion of all roadways in the zone that provide bicycle accommodation.

Reasoning: The presence of facilities designed for cyclists increases their comfort and safety. A greater presence of cycle facilities will improve the cycling experience.

Basic Methodology: The bicycle network layer was intersected with the cycle zone boundary, and then the lengths of each segment or partial segment that fell within a specific zone were summed. The resulting number was divided by the total length of all roadways in the zone to obtain the density of bikeways.

Figure 2. Bikeway Density CZA Scores



Roadway and Bikeway Connectivity

Table 2. Attractor Cycle Zone Factors

Cycle Zone	Roadway Connectivity	Bikeway Connectivity
1	0.88	0.58
2	0.85	0.25
3	0.90	0.00
4	0.90	0.00
5	0.88	0.00
6	0.89	0.00
7	0.75	0.00
8	0.77	0.00
9	0.74	0.00
10	0.63	0.00
11	0.75	0.00
12	0.79	0.00
13	0.87	0.00
14	0.90	0.00

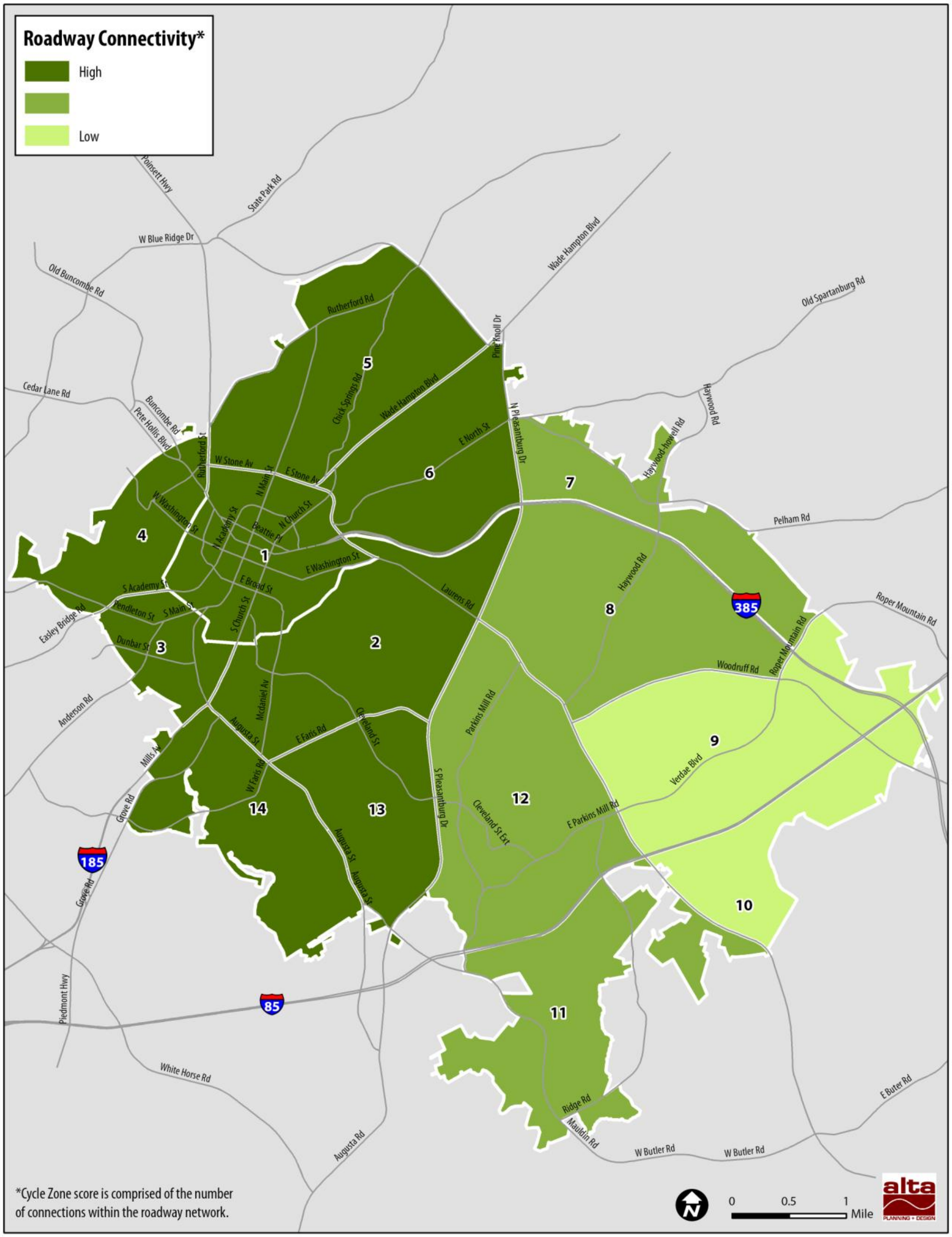
Roadway Connectivity:

Definition: A measure of roadway connectivity, this number, ranging from 0 – 1, represents the ratio of cul-de-sacs and three-way intersections to four- or more way intersections. The closer to one, the more grid-like the street pattern. An overall average score was calculated for each zone.

Reasoning: A zone with greater roadway connectivity will facilitate a better cycling experience. Riders will be able to easily go more places and have a greater route choice.

Basic Methodology: GIS was used to determine points in Greenville where one road was intersected by at least one other road. The location and number of roads at each intersection points were recorded. For each cycle zone, the overall number of intersections was summed as well as the number of intersections that were at least four-way. These numbers were used to determine the percentage of intersections that are four-ways or more.

Figure 3. Roadway Connectivity CZA Scores



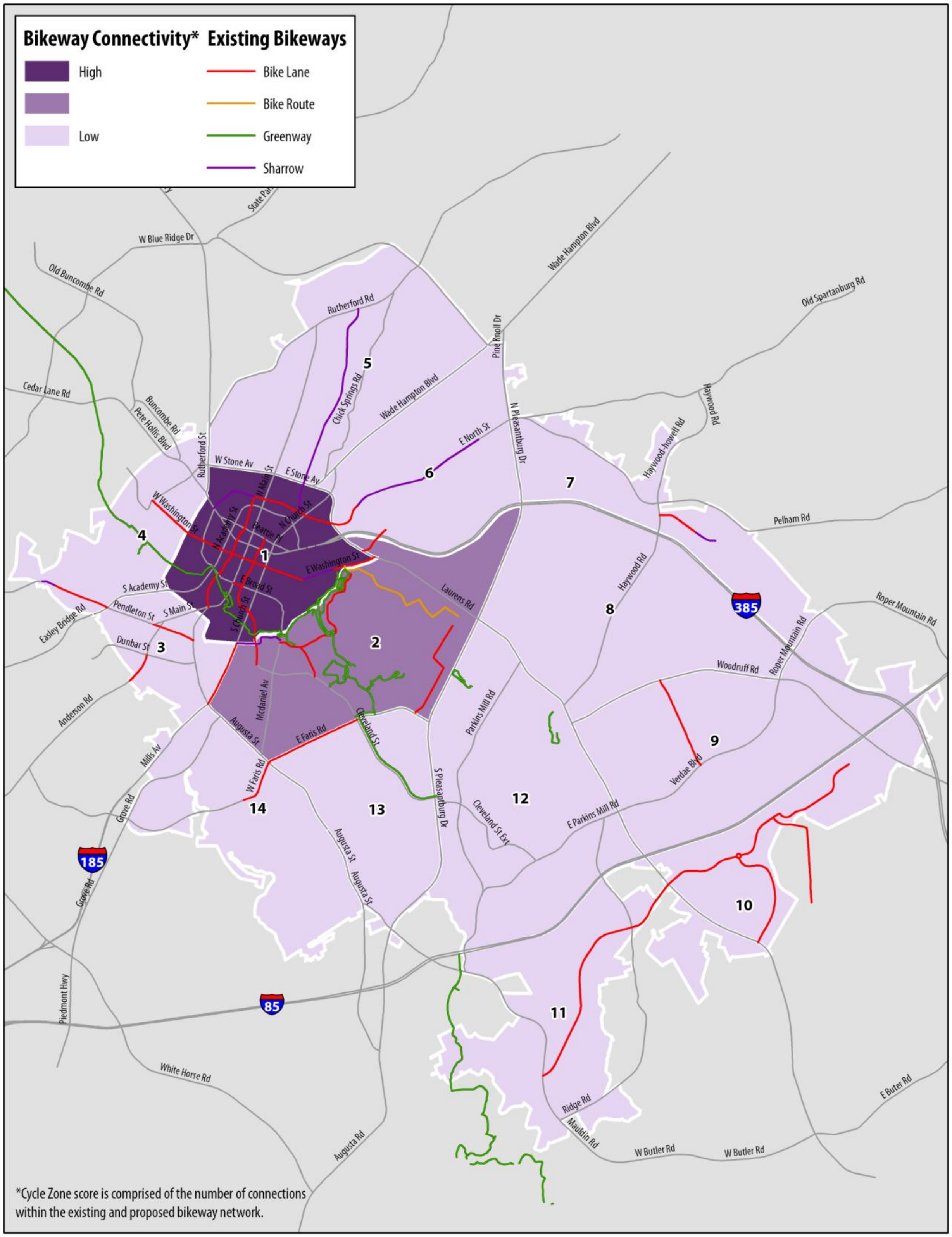
Bikeway Connectivity:

Definition: A measure of bikeway connectivity, this number, ranging from 0 – 1, represents the ratio of cul-de-sacs and three-way intersections that include bikeway facilities to four- or more way intersections that include bikeway facilities. The closer to one, the more grid-like the bikeway pattern. An overall average score was calculated for each zone.

Reasoning: A zone with greater bikeway connectivity will facilitate a better cycling experience. Riders will be able to easily go more places and have a greater route choice.

Basic Methodology: GIS was used to determine the points where segments of the existing bikeway network connect. The number of connected (four-way and T intersections) and disconnected (cul-de-sacs and bikeways that do not connect to other bikeways) points were recorded. For each cycle zone , a ratio of these intersections was calculated.

Figure 4. Bikeway Connectivity CZA Scores



Attractors

Table 3. Attractor Cycle Zone Factors

Cycle Zone	Area (Acres)	Commercial Land Use Acreage	% of Commercial Land Use per Zone	Public Facilities Acreage	% Public Facilities per Zone	Total % of Attractors per Zone
1	1,136	306	27	200	18	45
2	1,804	226	13	101	6	18
3	515	122	24	34	7	30
4	798	15	2	33	4	6
5	1,738	102	6	53	3	9
6	1,275	118	9	239	19	28
7	970	159	16	2	0	17
8	1,968	383	19	48	2	22
9	1,962	33	2	18	1	3
10	965	129	13	0	0	13
11	1,582	32	2	234	15	17
12	2,108	233	11	40	2	13
13	1,067	63	6	93	9	15
14	1,302	67	5	43	3	8

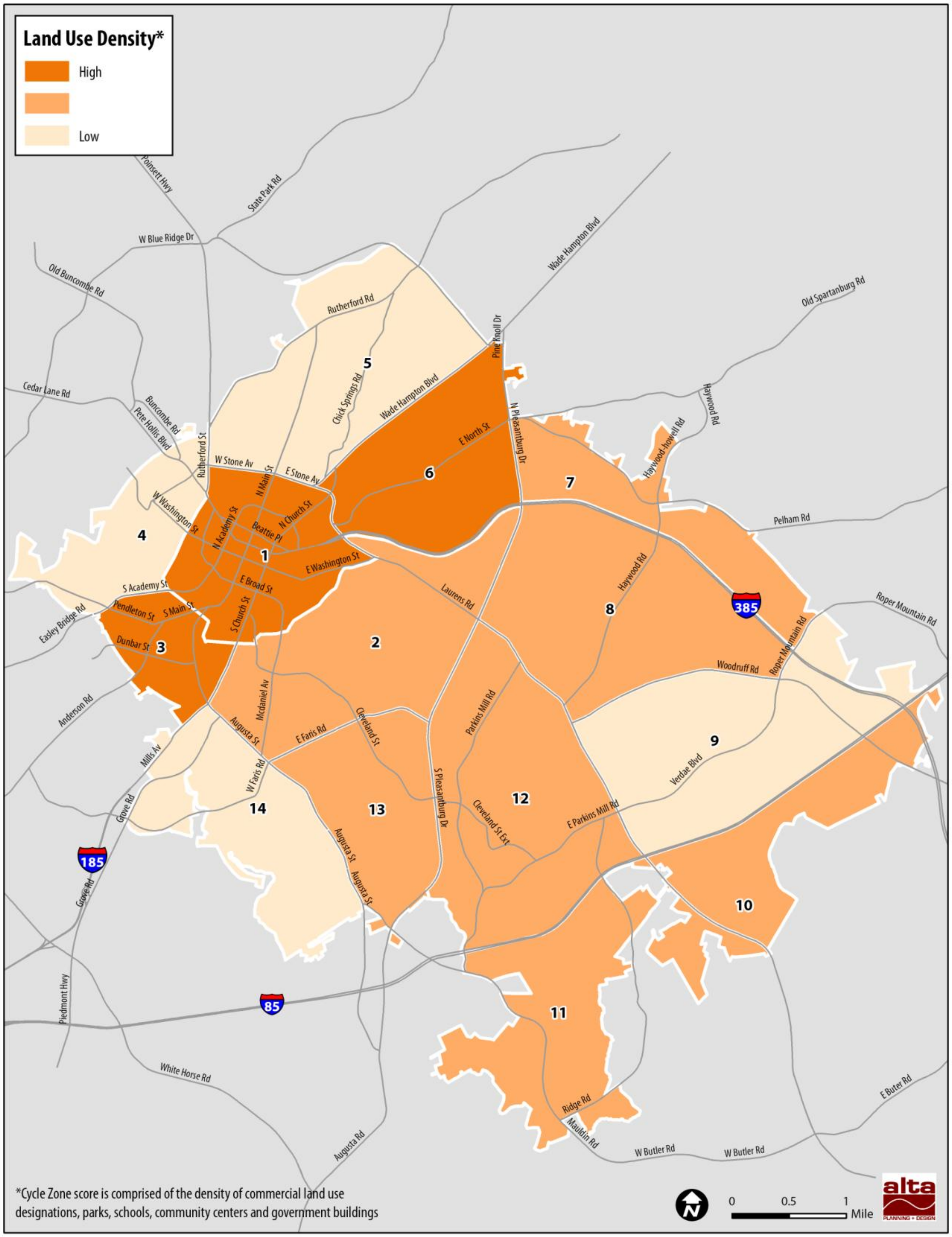
Commercial Land Uses and Public Facilities Acreage:

Definition: The density of commercial/retail land use designations and public facilities in each zone. Public facilities are defined as parks, schools and government buildings.

Reasoning: Commercial land uses and public facilities are important destinations for bicyclists.

Basic Methodology: In this analysis, commercial land uses were derived from Greenville's current zoning layer. The public facilities used in this analysis (defined above) were extracted from another layer received from the City of Greenville. These layers were intersected with the cycle zone boundaries, and then the total area of these land uses within each zone was summed.

Figure 4. Attractors CZA Scores


Land Use Density*
High
Low
1
2
3
4
5
6
7
8
9
10
11
12
13
14
W Blue Ridge Dr
Poinsett Hwy
State Park Rd
Old Buncombe Rd
Rutherford Rd
Chick Springs Rd
Wade Hampton Blvd
Pine Knoll Dr
Old Spartanburg Rd
Haywood Rd
Cedar Lane Rd
Buncombe Rd
Pete Hollis Blvd
Rutherford St
W Stone Av
E Stone Av
N Main St
E North St
N Pleasantburg Dr
Haywood-howell Rd
W Washington St
N Academy St
N Church St
Beattie Pl
E Washington St
Pelham Rd
S Academy St
E Broad St
Laurens Rd
Haywood Rd
Pendleton St
S Main St
S Church St
Easley Bridge Rd
Dunbar St
Roper Mountain Rd
Woodruff Rd
Anderson Rd
Mcdaniel Av
Cleveland St
Parkins Mill Rd
Augusta St
E Faris Rd
Mills Av
W Faris Rd
Verdae Blvd
S Pleasantburg Dr
Cleveland St Ext
E Parkins Mill Rd
Grove Rd
Augusta St
185
385
85
Piedmont Hwy
White Horse Rd
Ridge Rd
Mauldin Rd
W Butler Rd
E Butler Rd
Augusta Rd
*Cycle Zone score is comprised of the density of commercial land use designations, parks, schools, community centers and government buildings
0
0.5
1
Mile

Barriers

Table 4. Barrier Cycle Zone Factors

Cycle Zone	Area (Acres)	Highway Length	Highway Density	Rail Length	Rail Density	% of Roadways With Slope Over 5%	Total Barrier Density
1	1,136	7,772	6.84	0	0	2	8.57
2	1,804	882	0.49	0	0	3	3.30
3	515	0	0	6,407	12.44	0	12.88
4	798	0	0	71,520	89.62	1	90.20
5	1,738	0	0	19,965	11.49	3	14.13
6	1,275	23,243	18.23	0	0	2	20.10
7	970	3,982	4.11	0	0	1	4.91
8	1,968	36,081	18.33	16,718	8.49	1	27.45
9	1,962	59,492	30.32	7,600	3.87	1	34.89
10	965	33,797	35.01	15,594	16.15	0	51.37
11	1,582	11,391	7.20	0	0	0	7.57
12	2,108	17,423	8.26	0	0	2	10.11
13	1,067	0	0	0	0	1	1.48
14	1,302	0	0	0	0	2	1.66

Highways and Railroad Density:

Definition: Barriers that impede bicycling travel include interstates, railroads, and slope.

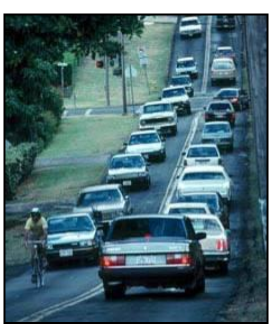
Reasoning: Limited crossing opportunities along highways and railroads force bicyclists to share major roadways with cars and/or force them to ride significantly out of direction to access a destination.

Basic Methodology: GIS was used to measure the length of interstates and railroads in each zone. This measure was divided by the total acreage of the zone to determine density.

Slope:

Definition: The length of roadways with an average slope over five percent for each cycling zone.

Example:



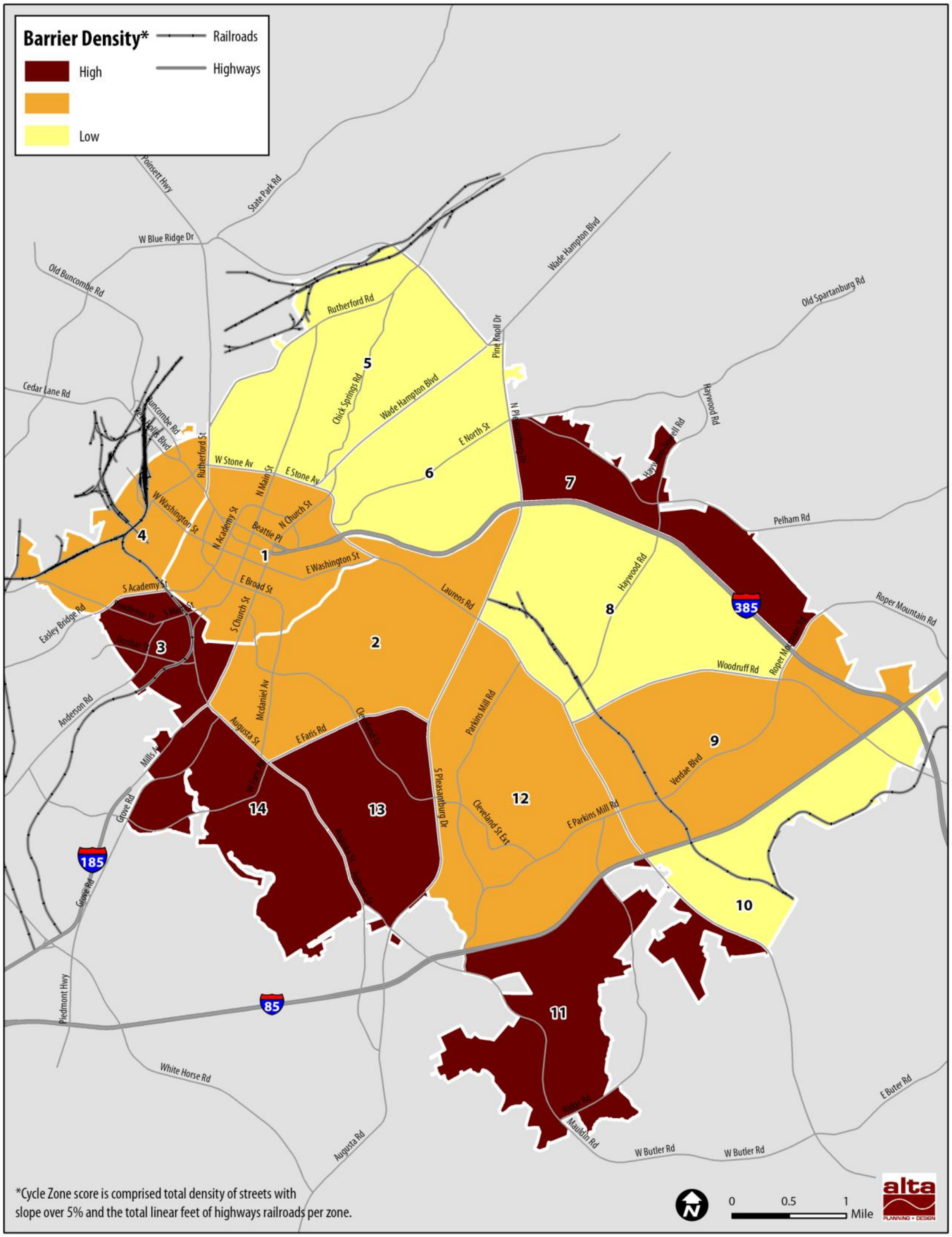
Steep hills can be significant barriers for some cyclists.

Flat terrain reduces barriers to cycling.

Reasoning: Topography can decrease the ease of cycling. A great cycle zone will be relatively flat. Topography is an issue that is difficult or impossible to change and is very important to consider when evaluating the bikability of a zone.

Basic Methodology: Elevation data from the USGS was used to determine the slope at 2 foot intervals throughout the city. Roadways were divided in 100 foot segments and average slope was recorded using GIS. Roadways with average slope over five percent were added together to estimate the footage of roadway with slope over five percent in each zone.

Figure 5. Combined Barriers CZA Scores



CZA Evaluation

The resulting scores for each factor for each zone were weighted and incorporated into the model. Each factor has a potential score of three, with the eight factors adding to a maximum of 24 points. A score of 24 therefore represents a zone with the most ideal bicycling conditions. The influence of each variable can be weighted by changing the percentage that a variable contributes to the final score.

For example, slope can account for five percent or 50 percent of a zone score depending on the need to emphasize or de-emphasize a factor. Table 5 represents the weights given to the factors in Greenville's CZA:

Table 5. CZA Factors and Weights

Bikeway Density	11%
Bikeway Connectivity	11%
Roadway Density	16%
Roadway Connectivity	16%
Land Use	19%
Topography	19%
Highway Density	4%
Railroad Density	4%

Greenville's designated bicycle network is clustered within the vicinity of Downtown. The network outside of this area is limited which causes travel to be facilitated primarily on the roadway network. Therefore, roadway density and connectivity were given higher weights than bikeway density and connectivity. The density and connectivity of bicycle facilities in Greenville is currently relatively low. Introducing new designated bicycle facilities have proven to increase cycling activity in cities across the country**.** As this analysis is used to evaluate existing bikabilty, it can also used to target future bicycle facility installation and analyze the impact of installing bike facilities in various zones.

While Greenville has a relatively level topography there are street segments with significant slopes and this is a major concern for citizens. Greenville also has an abundance of bikable destinations within and outside of Downtown Greenville. These include schools, parks, retail locations and other public places. Slope and land uses were therefore given the highest weights.

Highways and railroads are significant features that do not facilitate cycling activity but still have an influence on a network's connectivity. Greenville has two major highways that run through the southern and eastern sections of the City. Its railroads are generally isolated from the existing network with the exception of the westernmost part of West Washington Street which is adjacent to a cluster of rail. These features were therefore given a lower weight than the rest of the features.

Using CZA to Identify Cycling Potential

This tool can be used to highlight zones with issues such as topography and lack of road network connectivity that are difficult to easily solve through planning. Road network density, roadway connectivity, slope and destinations are all baseline factors that define the cycling potential in a given area. The development of the bicycle network will improve a zone from the baseline. Table 6 illustrates the relationship between the factors, scores and zones. This table can be used to understand the existing conditions in each zone, understand the factors that can be changed, and develop a strategy to develop each zone to its maximum cycling potential.

Table 6. Summary of CZA Scores

Cycle Zone	Bikeway Connectivity	Bikeway Density	Roadway Connectivity	Roadway Density	Land Use	Topography	Highway Density	Railroad Density	Composite CZA
1	High	Medium	High	Medium	High	Medium	Medium	High	High
2	Medium	Medium	High	Medium	Medium	Low	High	High	High
3	Low	Low	High	Medium	High	High	High	Medium	High
4	Low	Low	High	Medium	Low	High	High	Low	Low
5	Low	Low	High	Medium	Low	Low	High	Medium	Low
6	Low	Low	High	Medium	High	Medium	Low	High	Medium
7	Low	Low	Medium	Low	Medium	High	Medium	High	Low
8	Low	Low	Medium	Low	Medium	High	Low	Medium	Low
9	Low	Low	Medium	High	Low	High	Low	High	Low
10	Low	High	Low	High	Medium	High	Low	Medium	Medium
11	Low	Low	Medium	High	Medium	High	Medium	High	Medium
12	Low	Low	Medium	Low	Medium	Medium	Medium	High	Low
13	Low	Low	High	Low	Medium	Medium	High	High	Medium
14	Low	Low	High	Medium	Low	Medium	High	High	Medium

Value Key
High
Medium
Low

Goal Setting with CZA

This tool can also be used for goal setting by setting a target that all zones must rate a score of five or higher by 2020, for example. The CZA can be calibrated to highlight areas where additional cycling facilities will increase the rating from good to great, or poor to good. This could be accomplished by heavily weighting the scores associated with bike infrastructure density while holding the other factors equal.

Figure 6. Composite CZA Scores